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(73) Proprietor: MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
Kadoma-shi, Osaka-fu 571 (JP)

(72) Inventors:
- Ishizaki, Toshio
Kobe-shi, Hyogo-ken 658 (JP)
- Fujita, Mitsuhiro
Yamatokouriyama-shi, Nara-ken 639-11 (JP)
- Ikeda, Hikaru
Takatsuki-shi, Osaka-fu 569 (JP)
- Fujino, Takashi
Izumi-shi, Osaka-fu 594 (JP)

(74) Representative: Crawford, Andrew Birkby et al
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a compact planar type dielectric filter to be mainly used in a high frequency radio equipment such as a portable telephone set and the like.

2. Description of the Prior Art

Recently, there is an increasingly growing demand for further down-sizing a planar type dielectric filter which can be made thinner in structure as compared with a coaxial type one being widely used for portable telephone sets.

Explanations will be made below on the operation of a conventional dielectric filter of a laminated planar type as an example. A conventional planar dielectric filter comprises two thick dielectric layers, a first dielectric sheet on which two coil electrodes are formed, a second dielectric sheet on which one-side electrodes of two parallel plane capacitors are formed, a third dielectric sheet on which the other side electrodes of the two parallel plane capacitors are formed, a fourth dielectric sheet on which a shield electrode is formed, and a dielectric sheet which serves to protect the electrodes, which are laminated from the bottom in the order of the fourth dielectric sheet, one of the two thick dielectric layers, the first dielectric sheet, the other of the two thick dielectric layers, the second dielectric sheet, the third dielectric sheet and the dielectric sheet for electrode protection. In the dielectric filter constructed as above, the parallel plane capacitors are formed respectively between the capacitor electrodes confronted to each other. The parallel plane capacitors thus formed are connected through respective side electrodes to the coil electrodes in series to serve to act as a resonance circuit. The two coils are magnetically coupled to each other, and the input/output terminals are taken intermediately of the coil electrodes, thus forming a band-pass filter. (See, for example, Japanese Laid-Open Patent Publication NO. 3-72706.)

With the conventional dielectric filter structured as above, if the coil electrodes are disposed close to each other to decrease the distance therebetween for down-sizing, such a problem has been arisen that a good band-pass characteristic of a narrow band is difficult to be realized due to the fact that the magnetic coupling between the resonance circuits becomes too large.

US-A-4 418 324 discloses an interdigital filter comprising two dielectric layers, one of which comprising a plurality of electromagnetically coupled conductive strips, and the other acting as a set of capacitors arranged to operate on alternate strips to give transmission zero at a certain frequency.

An object of this invention is to provide a compact planar type dielectric filter capable of providing superior narrow-band band-pass characteristic.

In order to attain the above-mentioned object, a dielectric filter of this invention comprises

a first dielectric sheet (60c) having formed thereon a plurality of end short-circuited strip line resonators respectively composed of a plurality of strip lines (61a,61b) each of which has a length of about quarter-wavelength and which are formed in parallel, and

a second dielectric sheet (60d) having formed thereon a capacitor electrode (62a)

first and second dielectric sheets being laminated such that said capacitor electrode partially confronts at least one of said strip lines of said strip line resonators through said first or second dielectric sheet to constitute a parallel plane capacitor wherein

said plurality of strip lines (61a,61b) are formed closely to each other so that each adjacent two of said strip line resonators are directly magnetically coupled to each other, and wherein said first and second dielectric sheets being laminated such that said capacitor electrode (62a) partially confronts all of the electrodes of said strip line resonators (61a, 61b) to constitute a plurality of parallel plane capacitors such that said strip line resonators are electrically coupled to each other through said parallel plane capacitors whereby an inter-resonator coupling is performed in combination with said magnetic coupling and electric coupling;

characterized by further comprising third and fourth dielectric sheets (60e,60f) each having formed thereon a shield electrode (63a,63b), said third and fourth dielectric sheet being disposed so as to sandwich therebetween said first and second dielectric sheets (60c,60d) to shield said strip line resonators and said parallel plane capacitor with said shield electrodes.

With the structure as explained above, an equivalent coupling inductance between the end short-circuited strip line resonators becomes relatively larger than that between the coil electrodes of lumped constant elements, so that the inter-resonator coupling can be reduced. In addition, the coupling inductance component can be easily cancelled by the capacitance component of the parallel plane capacitors inserted in parallel, so that the inter-resonator coupling can be further reduced. As a result, a compact planar type dielectric filter having superior narrow-band band-pass characteristic can be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1(a) is an exploded perspective view of a dielectric filter.

Fig. 1(b) is a perspective view showing a first surface of a second dielectric substrate shown in Fig. 1(a).

Fig. 1(c) is a perspective view showing a ground electrode on the back surface of the first dielectric substrate shown in Fig. 1(a).

Fig. 2(a) is an equivalent circuit diagram for explaining the operation of the dielectric filter shown in Fig. 1(a).

Fig. 2(b) is another equivalent circuit of the circuit shown in Fig. 2 (a) expressed by using lumped constant elements.

Fig. 2(c) is still another equivalent circuit obtained by further equivalently changing the circuit shown in Fig. 2(b).

Fig. 3 is a diagram showing a coupling characteristic of an end short-circuited parallel strip line resonator for explaining the operation of the dielectric filter shown in Fig. 1(a).

Fig. 4(a) is an exploded perspective view of a second dielectric filter.

Fig. 4(b) is a perspective view showing electrodes of strip line resonators formed on a first dielectric substrate shown in Fig. 4(a).

Fig. 4(c) is a perspective view showing a second surface of a second dielectric substrate shown in Fig. 4 (a).

Fig. 5 is a cross-sectioned view of the dielectric filter shown in Fig. 4(a).

Fig. 6 is an exploded perspective view of a lamination-type dielectric filter according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A dielectric filter operating in the same manner as that of the present invention will be described below while referring to the accompanying drawings.

Fig. 1 is an exploded perspective view of a dielectric filter having a two-pole structure according to the first embodiment. In Fig. 1(a), 10a is a first dielectric substrate, 11a and 11b are end short-circuited strip line resonators of substantially a quarter-wavelength and 11c is a ground electrode. In addition, 10b is a second dielectric substrate to be laminated onto the first dielectric substrate 10a. Fig. 1(b) shows a first surface of the second dielectric substrate 10b for contacting with the first dielectric substrate 10a. In this first surface, first electrodes 12a and 12b of parallel plane capacitors the number of which is the same as the number of the resonators are formed so as to partially overlap the open-circuited ends of respective electrode patterns of the strip line resonators 11a and 11b. Fig. 1(a) shows a second surface of the second dielectric substrate 10b. On this second surface is formed a second electrode 12c of the parallel plane capacitors so as to be partially confronted to all the first electrodes of the parallel plane capacitors and to constitute one area as the whole. In addition, third electrodes 12d and 12e of the parallel plane capacitors are partially formed on the second surface of the second dielectric substrate in such areas that are confronted to the first electrodes thereof and that the second electrode is not formed, and grounded through connecting electrode terminals 13a and 13b. In addition, fourth electrodes 12f and 12g of the parallel plane capacitors are partially formed on the second surface of the second dielectric substrate in such areas that are confronted to the first electrodes thereof and that the second and third electrodes are not formed, thus being electrically connected to an external circuit through the capacitors formed by the fourth electrodes and first electrodes. The strip line resonator electrodes and ground electrode on the first dielectric substrate, and capacitor electrodes on the second dielectric substrate are all formed by a thick film printing method. The first and second dielectric substrates 10a and 10b are bonded to each other by applying a solder by a soldering method in respective areas where the open-circuited ends of electrode patterns of the strip line resonators 11a and 11b are overlapped with the first electrodes 12a and 12b of the parallel plane capacitors. Fig. 1(c) shows the ground electrode on the back side of the first dielectric substrate 10a, in which 11d and 11e are controlling slits for controlling the coupling between the resonators.

With the dielectric filter structured as above, the operation will be explained below by referring to Figs. 2 and 3. Fig. 2(a) is an equivalent circuit diagram of a dielectric filter of the first embodiment, Fig. 2(b) is another equivalent circuit of the circuit shown in Fig. 2(a) expressed by using lumped constant elements, and Fig. 2 (c) is still another equivalent circuit by further equivalently changing the circuit shown in Fig. 2(b). In Fig. 2 (a), strip line resonators 20a and 20b correspond respectively to the strip line resonators 11a and 11b shown in Fig. 1, capacitors C11a and C11b correspond respectively to the capacitors formed by the third electrodes 12d and 12e and the first electrodes 12a and 12b shown in Fig. 1, capacitors C12a and C12b correspond respectively to the capacitors formed by the second electrode 12c and the first electrodes 12a and 12b shown in Fig. 1, and capacitors 13a and 13b correspond respectively to the capacitors formed by the fourth electrodes 12f and 12g and the first electrodes 12a and 12b shown in Fig. 1. In addition, M shows a magnetic coupling between the strip line resonators 20a and 20b.

In Fig. 2(b), inductances L21a and L21b respectively represent equivalent inductance components of the strip line resonators 20a and 20b, capacitances C21a and C21b represent capacitance components of the strip line resonators 20a and 20b, respectively, and a parallel connection of the capacitances C11a and C11b shown in Fig. 2(a). A capacitance C22 represents a series connection of the capacitances C12a and C12b.

In Fig. 2(c), a coupling inductance L32, inductances L31a and L31b respectively represent inductances obtained by circuit-changing equivalently the inductances L21a and L21b and the magnetic coupling M shown in Fig. 2(b). Here, when the coupling inductance L32 is large, an impedance to be inserted in series between the resonators becomes large, so that the inter-resona-

for coupling becomes small.

When the inductances L21a and L21b are supposed to be equal to each other and expressed as L21, the coupling inductance L32 can be expressed as follows.

$$L32 = (L21+M) * (L21/M-1)$$

From this equation, it can be made clear that when L21 is constant, L32 increases with a decrease in M, and when the ratio of L32 to M is constant, L32 increases with an increase in M. The former case corresponds to the case when the space between the strip lines of the resonators is expanded and the latter case corresponds to the case when the line lengths thereof are made large or when the dielectric constant of the first dielectric substrate 10a is made large.

Fig. 3 shows the degree of the inter-resonator coupling of the end short-circuited strip line resonators having a length of quarter-wavelength disposed in parallel. In case of coil resonators, the inter-resonator coupling increases with an increase in the length of the parallel portions. In case of strip line resonators, the inter-resonator coupling becomes zero when the length thereof becomes just a quarter-wavelength, and small in the vicinity of such a length as above. As a result, in case of using strip line resonators, a desired inter-resonator coupling can be realized by appropriately designing the length thereof.

In addition, the magnetic coupling M can be controlled by providing controlling slit 11d or 11e on the grounding electrode of the back surface of the strip line resonators. The controlling slit 11d parallel to the strip line resonators makes large the odd-mode impedance only without changing the even-mode impedance between the parallel strip lines, so that the difference between the two impedances becomes small, and the magnetic coupling M becomes small equivalently to the loose coupling of resonators. The controlling slit 11e perpendicular to the strip line resonators causes the electric current on the grounding electrode to be bypassed, resulting in the insertion of an inductance component between the resonators. As a result, the magnetic coupling M becomes large equivalently to the tight coupling of resonators.

In addition, with the filter constructed according to this embodiment, the capacitance C22 which is a serial combination of the capacitance C12a and C12b of the parallel plate capacitors inserted between the strip line resonators is connected to the coupling inductance L32 in parallel thereby to offset the inductance component. The capacitance C22 and the coupling inductance L32 constitutes a parallel resonance circuit, and the impedance becomes infinite with the resonance frequency, resulting in forming the attenuation pole in the transfer characteristic.

As explained above, according to this arrangement, a plurality of end short-circuited strip line resonators having a length of about quarter-wavelength are formed parallel and closely to each other on the first dielectric substrate, the resonators thus adjacently disposed to each other are directly magnetically coupled to each other, the electrodes of the parallel plane capacitors formed on the second dielectric substrate and the strip line electrodes are bonded by applying solder by a soldering method in an area where they overlap each other so that the strip line resonators are electrically coupled to each other through the parallel plane capacitors, and the inter-resonator coupling can be made in combination of magnetic coupling and electric coupling, thus allowing the inter-resonator coupling to be reduced. As a result, such a small and planar type dielectric filter can be realized that has a small inter-resonator coupling and the attenuation pole as well as exhibits good narrow-band band-pass characteristic.

In addition, according to this arrangement all the capacitor electrodes necessary for making a filter can be formed on the second dielectric substrate, so that it can be made simple in structure, thus being capable of reducing the product variation of the dielectric filters that are produced.

In addition, in the explanations of this arrangement all the electrodes to be formed on the strip line resonators and capacitors were formed by the thick film printing technique, but not limited thereto, all of them may be formed thereon by means of a plating and etching method.

Further in addition, in this arrangement, the explanations were made on a dielectric filter having a two-pole structure, but not limited thereto, such a dielectric filter as to have a more than two-pole structure can be made in the same method, which is the same in the explanations of the following preferred embodiments.

A second dielectric filter similar to that of the present invention will be described below while referring to the drawings. Fig. 4 is an exploded perspective view of a dielectric filter according to this embodiment, and Fig. 5 is a cross-sectioned view of the dielectric filter of this embodiment taken along a line A - A' in Fig. 4(a).

In Fig. 4(a), 43 is a resin carrier, 40b is a second dielectric substrate, and 40a is a first dielectric substrate, which are laminated in this order. In addition, 41c is a ground electrode, and 41d and 41e are controlling slits for controlling the inter-resonator coupling. Fig. 4 (a) shows a first surface of the second dielectric substrate 40b. On this first surface, first electrodes 42a and 42b of parallel plane capacitors the number of which is the same as the number of the resonators, are formed so as to partially overlap the open-circuited ends of respective electrode patterns of strip line resonators. Fig. 4(b) shows the surface of the first dielectric substrate 40a on which the electrodes of the strip line resonators are formed, in which 41a and 41b are strip line resonators having a folded structure. Fig. 4(c) shows a second surface of the second dielectric substrate 40b. On this

second surface, a second electrode 42c of the parallel plane capacitors is formed so as to be partially confronted to all the first electrodes of the parallel plane capacitors and to constitute one area as the whole. In addition, a third electrode 42d of the parallel plane capacitors is partially formed on the second surface thereof so as to be confronted to the first electrodes thereof in such an area that the second electrode is not formed. The third electrode 42d is such an electrode that the electrodes 12d and 12e shown in Fig. 1 are formed in one united body and grounded through a metal terminal 432a for ground electrode use. Also, fourth electrodes 42f and 42g of the parallel plane capacitors are partially formed on the second surface thereof to be confronted respectively to the first electrodes thereof in such an area that the second and third electrodes are not formed, and connected to an external circuit through capacitors to be respectively formed by the fourth electrodes 42f and 42g and the first electrodes 42a and 42b. In addition, the first and second dielectric substrates 40a and 40b are bonded to each other by applying a solder by a soldering method in such areas that the open-circuited ends of the electrode patterns of the strip line resonators 41a and 41b and the first electrodes 42a and 42b of the parallel plane capacitors are superposed, respectively.

The dielectric filter of this embodiment is different in structure from that of the first arrangement in (1) that the strip line resonators 41a and 41b having a folded structure are introduced as a resonator, (2) that the bonded substrate body is mounted onto the resin carrier 43, and (3) that the strip line resonators of a groove type are formed on the first dielectric substrate. The structure of the other component parts is substantially the same as that shown in Fig. 1.

With the dielectric filter structured as above, the operation will be explained while emphasizing the different points from that of the first arrangement.

The first different point is that the strip line resonators 41a and 41b each having a folded structure respectively have the line widths changed from wide width portions 411a and 411b to narrow width portions 412a to 412b of the strip line shorter than a quarter-wavelength, and connected to respective ground electrodes on the back surface thereof through band-shaped electrodes 413a and 413b each having the same width as that of the narrow width portion formed on the side of the first dielectric substrate 40a. The ground electrodes can be extended in the line length equivalently by providing notched slits 414a and 414b at respective connecting points, and the resonance frequency can be controlled by changing the lengths of the notched slits. The strip line resonator of the folded structure as shown above can be small-sized without degrading the value of Q-factor so much. A best combination of the value of Q-factor and the size of the resonator can be obtained when the line widths of the band-shaped electrodes 413a and 413b are equal to the widths of the narrow width portions 412a and 412b of the strip line resonators 41a and 41b. When the line widths of the band-shaped electrodes are smaller than the widths of the narrow width portions, the value of Q-factor will be sacrificed and when the former are larger than the latter, the size of the resonator will be sacrificed.

The second point is that the resin carrier 43 has an integral structure of a resin 433 with a metal terminal 431 for input/output electrode use and a metal terminal 432a for ground electrode use. This means that an improvement in terminal strength to be used as a surface mounted device (SMD) can be realized. In addition, for the purpose of shielding the filter, a shield plate 434 which is connected to the metal terminal 432b for ground electrode use is insertedly provided into the bottom surface of the resin carrier 43. The metal terminal 432b for ground electrode use is connected to the ground electrode 41c of the first dielectric substrate 40a to shield the upper portion of the filter. In order to reduce the filter loss to minimize the degradation of filter characteristic, it is effective to provide a concave groove 435 on the upper surface of the resin carrier 43 so as to form an air layer between the shield plate 434 and the bonded substrates body of the first and second dielectric substrates 40a and 40b.

The third point is that the strip line resonators 41a and 41b to be formed in a groove form on the first dielectric substrate 40a are made in such a manner that the grooves to form the resonators are pressure-molded and fired in the process of producing the first dielectric substrate, a thick film electrode material is applied on the entire surface of the substrate, and thereafter, the electrode material applied in the area where the grooves are not formed are removed by a polishing method thereby forming the electrodes of the strip line resonators. This method is superior in mass-production to the thick film printing method. In this method, the substrate may be entirely immersed into a solution of a thick film electrode material to adhere an electrode material onto the entire surface of the substrate and then fired, or an electrode material may be plated on the entire surface of the substrate by an electroless plating method, so that strong adhesion of the electrode material onto the ceramic substrate can be obtained. As a result, the adhesion of the electrodes and the substrate can be outstandingly improved especially in such an area that the strip line resonators at the edge of the substrate are connected to the respective band-shaped electrodes. Consequently, the electrode resistance to a high-frequency current can be reduced and the loss of resonators can be decreased. In addition, with the groove-type strip line resonator, the high-frequency current can be concentrated in the area where the bottom surface and side surface of the groove are to be in contact to each other. On the other hand, with a general planar type strip line resonator, the high frequency current will be concentrated in a rugged area peripherally of the strip line, thus a greater part of the loss of the resonator being generated at such area. On the other hand, with the groove-type

strip line resonator, the electrode in the area where the bottom surface and the side surface thereof are contacted each other does not have such a ragged area that the side area has. Accordingly, the electrode resistance to high-frequency current in the contacting area becomes smaller than in the side area. As a result, the groove-type strip line resonator can be made small in resonator loss as compared with the plane-type strip line resonator.

As explained above, the dielectric filter according to this arrangement makes it possible to realize a compact size without degrading the filter characteristic by using a strip line resonator having a folded-type structure. In addition, by using a carrier made of a resin, the terminal electrode strength and shielding property of the filter can be outstandingly improved. Further in addition, by using a groove-type strip line resonator, the loss of the filter can be decreased and the productivity can be outstandingly improved.

Also, similar to the first arrangement, it is needless to say that the inter-resonator coupling can be controlled by providing a controlling slit 41d or 41e on the grounding electrode 41c on the back surface thereof. In addition, in combination with the frequency controlling method by using the notched slits 414a and 414b of the strip line resonators having a folded structure, the filter characteristic can be controlled only on the back surface of the resonator. This fact is very important for the dielectric filter of this embodiment in which the component parts other than the ground electrode on the back surface are substantially covered with the resin carrier.

A dielectric filter according to the present invention will be described below while referring to the drawings.

Fig. 6 is a perspective view of a dielectric filter of this embodiment, in which 60a and 60b are thick dielectric layers. A dielectric sheet 60c has strip line resonator electrodes 61a and 61b formed thereon, and a dielectric sheet 60d has a second electrode 62a, a third electrode 62b and fourth electrodes 62c and 62d of parallel plane capacitors formed thereon. The strip line resonator electrodes 61a and 61b have the strip lines whose short-circuited ends are narrowed in width of the strip line, that is, narrowed from a wide width portion to a narrow width portion, resulting in realizing down-sizing. In addition, a shield electrode 63a is formed on a dielectric sheet 60e, and a shield electrode 63d is formed on a dielectric sheet 60f. These dielectric sheets, dielectric layers and an electrode protective dielectric sheet 60g are laminated to obtain a lamination body.

With the dielectric filter structured as explained above, the operation will be explained below.

First, the strip line resonator electrodes 61a and 61b and the second electrode 62a, third electrode 62b and fourth electrodes 62c and 62d which are confronted to the electrodes 61a and 61b respectively form parallel plane capacitors therebetween. The second electrode 62a of the parallel plane capacitors serves to act as an interresonator coupling capacitor. The third electrode 62b serves to act as a parallel capacitor for lowering the resonance frequency of the strip line resonators. The fourth electrodes 62c and 62d serve to act as input/output coupling capacitors. The fourth electrodes 62c and 62d are connected respectively to the side electrodes 64a and 64b to be used as input/output terminals. The lower shield electrode 63a and the upper shield electrode 63b are connected to side electrodes 65a, 65b and 65c respectively to be used as ground terminals.

The dielectric filter of this embodiment is different from that of the first arrangement in that lamination is made so that the first electrodes of the parallel plane capacitor are used in common with the electrodes of the strip line resonators. The lamination structure according to the present invention makes it possible to be simple in structure and small in size as well as to realize a shield. In addition, according to the present invention, all the electrodes of the strip line resonators are formed on the dielectric sheet 60c and all the capacitor electrodes are formed on the dielectric sheet 60d by a printing method, so that the electrode printing may be applied only for two dielectric sheets and two shield electrodes. This means that the number of printing processes can be made small and yet, the variation of filter characteristic can be reduced.

Claims

1. A dielectric filter comprising:

   a first dielectric sheet (60c) having formed thereon a plurality of end short-circuited strip line resonators respectively composed of a plurality of strip lines (61a,61b) each of which has a length of about quarter-wavelength and which are formed in parallel; and
   a second dielectric sheet (60d) having formed thereon a capacitor electrode (62a),
   first and second dielectric sheets being laminated such that said capacitor electrode partially confronts at least one of said strip lines of said strip line resonators through said first or second dielectric sheet to constitute a parallel plane capacitor, wherein
   said plurality of strip lines (61a,61b) are formed closely to each other so that each adjacent two of said strip line resonators are directly magnetically coupled to each other, and wherein said first and second dielectric sheets being laminated such that said capacitor electrode (62a) partially confronts all of the electrodes of said strip line resonators (61a,61b) to constitute a plurality of parallel plane capacitors such that said strip line resonators are electrically coupled to each other through said parallel plane capacitors whereby an inter-resonator coupling is performed in combination with said magnetic cou-

pling and electric coupling

characterized by further comprising third and fourth dielectric sheets (60e 60f) each having formed thereon a shield electrode (63a 63b), said third and fourth dielectric sheet being disposed so as to sandwich therebetween said first and second dielectric sheets (60c 60d) to shield said strip line resonators and said parallel plane capacitor with said shield electrodes

2. A dielectric filter according to claim 1, further comprising a second capacitor electrode (62b) formed on said second dielectric sheet so as to partially confront said strip lines of said strip line resonators to thereby constitute second parallel plane capacitors, said second capacitor electrode being adapted to be connected to a ground.

3. A dielectric filter according to any preceding claim, further comprising a third capacitor electrode (62c) formed on said second dielectric sheet so as to partially confront one of said strip lines of said strip line resonators to thereby constitute a third parallel plane capacitor, and a fourth capacitor electrode (62d) formed on said second dielectric sheet so as to partially confront another of said strip lines of said strip line resonators to thereby constitute a fourth parallel plane capacitor, said third and fourth capacitor electrodes being adapted to be connected to input and output lines, respectively.

4. A dielectric filter according to any preceding claim, further comprising an additional dielectric sheet (60g) provided on an outermost one of the shield electrodes to protect the outermost shield electrode.

5. A dielectric filter according to any preceding claim, wherein said first through fourth dielectric sheets are laminated in the order of said third, first, second and fourth dielectric sheets with a first thick dielectric plate (60a) disposed between said third and first dielectric sheets and with a second thick dielectric plate (60b) disposed between said second and fourth dielectric sheets so that each of a distance between said shield electrode on said third dielectric sheet and said strip lines of said strip line resonators and a distance between said shield electrode on said fourth dielectric sheet and said capacitor electrode is larger than a distance between said strip lines of said strip line resonators and said capacitor electrode

6. A dielectric filter according to any preceding claim further comprising at least two ground electrodes (65a, 65b, 65c) respectively formed on different side surfaces of each of said first through fourth dielectric sheets and connected to said shield electrode

7. A dielectric filter according to any preceding claim further comprising at least two ground electrodes (65a, 65b 65c) respectively formed on opposite side surfaces of each of said first through fourth dielectric sheets and connected to said shield electrode, a pattern of said ground electrodes on one of said opposite side surfaces being different from a pattern of said ground electrodes on the other of said opposite side surfaces

8. A dielectric filter according to any preceding claim wherein short-circuited ends of all of said strip line resonators extends to a same side surface of said first dielectric sheet and connected to a ground electrode (65a, 65b) formed on said side surface

9. A dielectric filter according to claim 8, wherein another ground electrode (65c) is formed on a side surface of said first dielectric sheet closer to open-circuited ends of said strip line resonators

10. A dielectric filter according to any preceding claim, further comprising an input terminal electrode (64a) and an output terminal electrode (64b) which are formed on one side surface of said first dielectric sheet, and a ground electrode (65c) formed between said input and output terminal electrodes on said side surface.

11. A dielectric filter according to any preceding claim, wherein said shield electrode on each of said third and fourth dielectric sheets is formed to leave a margin along the periphery of the corresponding dielectric sheet.

12. A dielectric filter according to any preceding claim, wherein said shield electrodes formed on said third and fourth dielectric sheets are the same in shape.

13. A dielectric filter according to any preceding claim, wherein a line width of a short-circuited end of a strip line of each of said strip line resonators is narrower than a line width of an open-circuited end of said strip line.

Patentansprüche

1. Ein dielektrisches Filter, umfassend:

eine erste, dielektrische Lamelle (60c), auf der eine Mehrzahl von am Ende kurzgeschlossenen Streifenleitungsresonatoren jeweils aus einer Mehrzahl von Streifenleitungen (61a, 61b) gebildet ist, von denen jede eine Länge von ungefähr einer Viertelwellenlänge hat und die par-

alle gebildet sind und

eine zweite dielektrische Lamelle (60d), auf der eine Kondensatorelektrode (62a) gebildet ist

die erste und die zweite dielektrische Lamelle sind so geschichtet, daß die genannte Kondensatorelektrode teilweise wenigstens einer der genannten Streifenleitungen der genannten Streifenleitungsresonatoren durch die genannte erste oder zweite, dielektrische Lamelle hindurch gegenüberstehen, um einen parallelen, ebenen Kondensator zu bilden, worin

die genannte Mehrzahl von Streifenleitungen (61a, 61b) nahe beieinander gebildet ist, so daß jeweils zwei benachbarte der genannten Streifenleitungsresonatoren unmittelbar magnetisch miteinander gekoppelt sind, und worin die genannte erste und zweite, dielektrische Lamelle so geschichtet sind, daß die genannte Kondensatorelektrode (62a) teilweise allen Elektroden der genannten Streifenleitungsresonatoren (61a, 61b) gegenübersteht, um eine Mehrzahl von parallelen, ebenen Kondensatoren zu bilden, so daß die genannten Streifenleitungsresonatoren elektrisch miteinander durch die genannten parallelen, ebenen Kondensatoren gekoppelt sind, wodurch eine Zwischenresonatorkopplung in Kombination mit der genannten magnetischen Kopplung und der elektrischen Kopplung ausgeführt wird;

dadurch gekennzeichnet, daß es des weiteren eine dritte und eine vierte, dielektrische Lamelle (60e, 60f) umfaßt, auf denen jeweils eine Abschirmelektrode (63a, 63b) gebildet ist, wobei die genannte dritte und vierte, dielektrische Lamelle so angeordnet sind, daß dazwischen die genannte erste und die genannte zweite, dielektrische Lamelle (60c, 60d) eingefügt sind, um die genannten Streifenleitungsresonatoren und den genannten parallelen, ebenen Kondensator mit den genannten Abschirmelektroden abzuschirmen.

2. Ein dielektrisches Filter gemäß Anspruch 1, das des weiteren eine zweite Kondensatorelektrode (62b) umfaßt, die auf der genannten zweiten, dielektrischen Lamelle so gebildet ist, daß sie teilweise den genannten Streifenleitungen der genannten Streifenleitungsresonatoren gegenübersteht, und dadurch zweite, parallele, ebene Kondensatoren zu bilden, wobei die genannte zweite Kondensatorelektrode geeignet ist, mit Masse verbunden zu werden.

3. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, das des weiteren eine dritte Kondensatorelektrode (62c) umfaßt, die auf der genannten zweiten, dielektrischen Lamelle so gebildet ist, daß sie teilweise einer der genannten Streifenleitungen der genannten Streifenleitungsresonatoren gegenüber steht, um dadurch einen dritten, parallelen, ebenen Kondensator zu bilden und eine vierte Kondensatorelektrode (62d), die auf der genannten zweiten, dielektrischen Lamelle so gebildet ist, daß sie teilweise einer anderen der genannten Streifenleitungen der genannten Streifenleitungsresonatoren gegenüber steht, um dadurch einen vierten, parallelen, ebenen Kondensator zu bilden, wobei die Elektroden des genannten dritten und vierten Kondensators mit einer Eingangs- bzw. Ausgangsleitung verbunden werden können.

4. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, das des weiteren eine zusätzliche, dielektrische Lamelle (60g) umfaßt, die auf einer äußersten der Abschirmelektroden vorgesehen ist, um die äußerste Abschirmelektrode zu schützen.

5. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, worin die genannte erste bis vierte, dielektrische Lamelle in der Reihenfolge der genannten dritten, ersten, zweiten und vierten, dielektrischen Lamelle aufeinander geschichtet sind, wobei einer erste, dicke, dielektrische Platte (60a) zwischen der genannten dritten und ersten, dielektrischen Lamelle angeordnet ist, und wobei eine zweite, dicke, dielektrische Platte (60b) zwischen der genannten zweiten und vierten, dielektrischen Lamelle so angeordnet ist, daß jeweils der Abstand zwischen der genannten Abschirmelektrode auf der genannten dritten, dielektrischen Lamelle und den genannten Streifen leitungen der genannten Streifenleitungsresonatoren und der Abstand zwischen der genannten Abschirmelektrode auf der genannten vierten, dielektrischen Lamelle und der genannten Kondensatorelektrode größer als ein Abstand zwischen den genannten Streifenleitungen der genannten Streifenleitungsresonatoren und der genannten Kondensatorelektrode ist.

6. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, das des weiteren wenigstens zwei Masselektroden (65a, 65b, 65c) umfaßt, die jeweils auf unterschiedlichen Seitenoberfläche von jeder der genannten ersten bis vierten, dielektrischen Lamelle gebildet sind und mit der genannten Abschirmelektrode verbunden sind.

7. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, das des weiteren wenigstens zwei Masseelektroden (65a, 65b, 65c) umfaßt, die jeweils auf gegenüberliegenden Seiten-

oberflächen von jeder der genannten ersten bis vierten dielektrischen Lamelle gebildet und mit der genannten Abschirmelektrode verbunden sind, wobei ein Muster der genannten Masseelektroden auf einer der genannten gegenüberstehenden Seitenoberflächen von einem Muster der genannten Masseelektroden auf der anderen der genannten gegenüberstehenden Seitenoberflächen verschieden ist.

8. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, worin sich die kurzgeschlossenen Enden von allen der genannten Streifenleitungsresonatoren zu derselben Seitenoberfläche der genannten ersten, dielektrischen Lamelle erstrecken und mit einer Masseelektrode (65a, 65b) verbunden sind, die auf der genannten Seitenoberfläche gebildet ist.

9. Ein dielektrisches Filter, gemäß Anspruch 8, worin eine weitere Masseelektrode (65c) auf einer Seitenoberfläche der genannten ersten dielektrischen Lamelle näher zu den offenen Enden der genannten Streifenleitungsresonatoren gebildet sind.

10. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, das des weiteren eine Eingangsanschlußelektrode (64a) und eine Ausgangsanschlußelektrode (64b) umfaßt, die auf einer Seitenoberfläche der genannten ersten dielektrischen Lamelle gebildet sind, und eine Masseelektrode (65c), die zwischen der genannten Eingangs- und Ausgangsanschlußelektrode auf der genannten Seitenoberfläche gebildet ist.

11. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, worin die genannte Abschirmelektrode auf jeder der genannten dritten und vierten, dielektrischen Lamellen gebildet ist, einen Rand entlang dem Umfang der entsprechenden dielektrischen Lamelle zu lassen.

12. Ein dielektrisches Filter gemäß irgendeinem vorhergehenden Anspruch, worin die genannten Abschirmelektroden, die auf der genannten dritten und vierten dielektrischen Lamelle gebildet sind, die gleiche Form haben.

13. Ein dielektrisches Filter, gemäß irgendeinem vorhergehenden Anspruch, worin die Leitungsweite am kurzgeschlossenen Ende einer Streifenleitung von jedem der genannten Streifenleitungsresonatoren schmaler als die Leitungsweite an einem offenen Ende der genannten Streifenleitung ist.

Revendications

1. Filtre de diélectrique comprenant

- une première feuille de diélectrique (60c) possédant une pluralité de resonateurs en ligne en bandes à extrémités en court-circuit respectivement composés d'une pluralité de lignes en bandes (61a, 61b) possédant chacune une longueur d'environ un quart de longueur d'onde et formées en parallèle, et
- une seconde feuille de diélectrique (60d) possédant une électrode de condensateur (62a) formée dessus;

les première et seconde feuilles de diélectrique étant déposées en couches de telle façon que ladite électrode de condensateur soit partiellement en face d'au moins une desdites lignes en bande desdits résonateurs en ligne en bandes, via ladite première ou seconde feuille de diélectrique, pour constituer un condensateur plan en parallèle;
filtre dans lequel ladite pluralité de lignes en bandes (61a, 61b) sont formées proches l'une de l'autre de telle façon que chaque paire adjacente desdits résonateurs en ligne en bandes soient directement couplées, de façon magnétique, l'une à l'autre et dans lequel lesdites première et seconde feuilles de diélectrique sont déposées en couches de telle façon que ladite électrode de condensateur (62a) sont partiellement en face de toutes les électrodes desdits résonateurs en ligne en bandes (61a, 61b) pour constituer une pluralité de condensateurs plans en parallèle de telle façon que lesdits résonateurs en ligne en bandes soient couplés, de façon électrique, l'un à l'autre via lesdits condensateurs plans en parallèles, un couplage entre résonateur étant effectué en combinaison avec ledit couplage magnétique et ledit couplage électrique;
filtre caractérisé en ce qu'il comprend, de plus, des troisième et quatrième feuilles de diélectrique (60e, 60f) possédant chacune une électrode de blindage (63a, 63b), lesdites troisième et quatrième feuilles de diélectrique étant disposées de façon à prendre en sandwich lesdites première et seconde feuilles de diélectrique (60c, 60d) afin d'isoler lesdits résonateurs en ligne en bandes et ledit condensateur plan en parallèle desdites électrodes de blindage

2. Filtre de diélectrique selon la revendication 1, comprenant, de plus, une seconde électrode de condensateur (62b) formée sur ladite seconde feuille de diélectrique de façon à faire face, de façon partielle, auxdites lignes en bandes desdits résona-

teurs en ligne en bandes pour constituer ainsi des seconds condensateurs plans en parallèle, ladite seconde électrode de condensateur étant prévue pour être raccordée à une masse.

3. Filtre de diélectrique selon l'une quelconque des revendications précédentes, comprenant, de plus, une troisième électrode de condensateur (62c) formée sur ladite seconde feuille de diélectrique de façon à être partiellement en face d'une desdites lignes en bandes desdits résonateurs en ligne en bande pour constituer ainsi un troisième condensateur plan en parallèle, et une quatrième électrode de condensateur (62d) formée sur ladite seconde feuille de diélectrique de façon à être partiellement en face d'une autre desdites lignes en bande desdits résonateurs en ligne en bande pour constituer ainsi un quatrième condensateur plan en parallèle, lesdites troisième et quatrième électrodes de condensateur étant prévues pour être raccordées à des lignes respectives d'entrée et de sortie.

4. Filtre de diélectrique selon l'une quelconque des revendications précédentes, comprenant, de plus, une feuille additionnelle de diélectrique (60g) prévue sur une électrode la plus externe des électrodes de blindage pour protéger l'électrode de blindage la plus externe.

5. Filtre de diélectrique selon l'une quelconque des revendications précédentes, dans lequel lesdites première à quatrième feuilles de diélectrique sont déposées dans l'ordre selon lesdites troisième, première, seconde et quatrième feuilles de diélectrique avec interposition d'une première plaque épaisse de diélectrique (60a) entre lesdites troisième et première feuilles de diélectrique et avec interposition d'une seconde plaque épaisse de diélectrique (60b) entre lesdites seconde et quatrième feuilles de diélectrique de telle façon que chaque distance entre ladite électrode blindage sur ladite troisième couche de diélectrique et lesdites lignes en bande desdits résonateurs en ligne en bande et une distance entre ladite électrode de blindage sur ladite quatrième feuille de diélectrique et ladite électrode de condensateur soit plus grande qu'une distance séparant lesdites lignes en bandes desdits résonateurs en lignes en bandes et ladite électrode de condensateur.

6. Filtre de diélectrique selon l'une quelconque des revendications précédentes, comprenant, de plus, au moins deux électrodes de masse (65a, 65b, 65c) respectivement formées sur des surfaces latérales différentes de chacune desdites première à quatrième feuilles de diélectrique et raccordées à ladite électrode de blindage.

7. Filtre de diélectrique selon l'une quelconque des revendications précédentes comprenant, de plus, au moins deux électrodes de masse (65a, 65b, 65c) respectivement formées sur des surfaces latérales opposées de chacune desdites première à quatrième feuille de diélectrique et raccordées à ladite électrode de blindage, une configuration desdites électrodes de masse sur une desdites surfaces latérales opposées étant différente de celle desdites électrodes de masse sur l'autre desdites surfaces latérales opposées.

8. Filtre de diélectrique selon l'une quelconque des revendications précédentes, dans lequel les extrémités en court-circuit de tous lesdits résonateurs en ligne en bande s'étendent sur une même surface latérale de ladite première feuille de diélectrique et sont raccordées à une électrode de masse (65a, 65b) formée sur ladite surface latérale.

9. Filtre de diélectrique selon la revendication 8, dans lequel une autre électrode de masse (65c) est formée sur une surface latérale de ladite première couche de diélectrique plus proche des extrémités en court-circuit desdits résonateurs en ligne en bandes.

10. Filtre de diélectrique selon l'une quelconque des revendications précédentes, comprenant, de plus, une électrode de borne d'entrée (64a) et une électrode de borne de sortie (64b) qui sont formées sur une surface latérale de ladite première feuille de diélectrique, et une électrode de masse (65c) formée entre lesdites électrodes de borne d'entrée et de sortie sur ladite surface latérale.

11. Filtre de diélectrique selon l'une quelconque des revendications précédentes, dans lequel ladite électrode de blindage sur chacune desdites troisième et quatrième feuilles de diélectrique est formée pour laisser une marge le long de la périphérie de la feuille de diélectrique correspondante.

12. Filtre de diélectrique selon l'une quelconque des revendications précédentes, dans lequel lesdites électrodes de blindage formées sur lesdites troisième et quatrième feuilles de diélectrique ont la même forme.

13. Filtre de diélectrique selon l'une quelconque des revendications précédentes, dans lequel une largeur de ligne d'une extrémité en court-circuit d'une ligne en bandes de chacun desdits résonateurs en ligne en bandes est plus étroite qu'une largeur de ligne d'une extrémité en circuit ouvert de ladite ligne en bande.

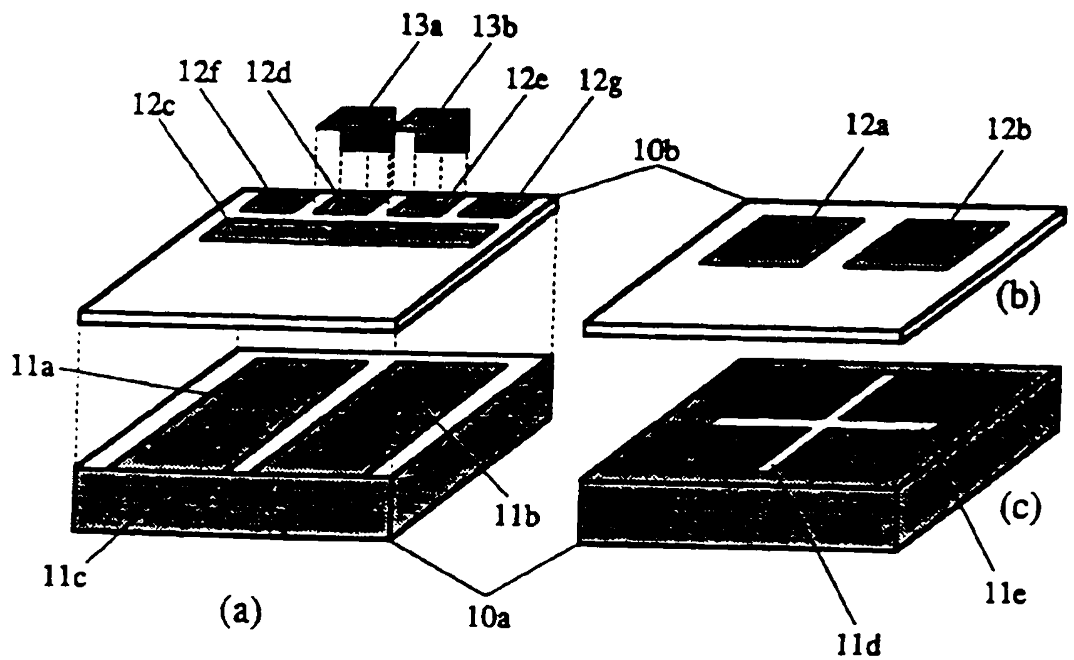
13a
13b
12f
12d
12e
12g
12c
10b
12a
12b
(b)
11a
11b
(c)
11c
11e
(a)
10a
11d

Fig.1

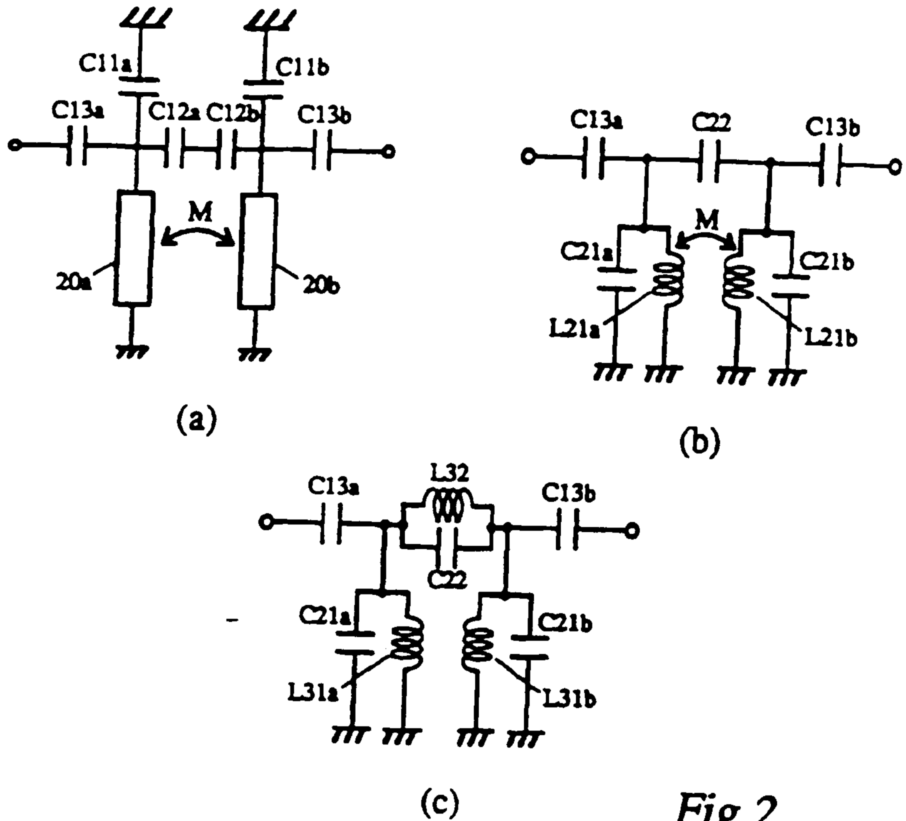
C11a
C11b
C13a
C12a
C12b
C13b
M
20a
20b
(a)
C13a
C22
C13b
M
C21a
C21b
L21a
L21b
(b)
L32
C13a
C13b
C22
C21a
C21b
L31a
L31b
(c)

Fig.2

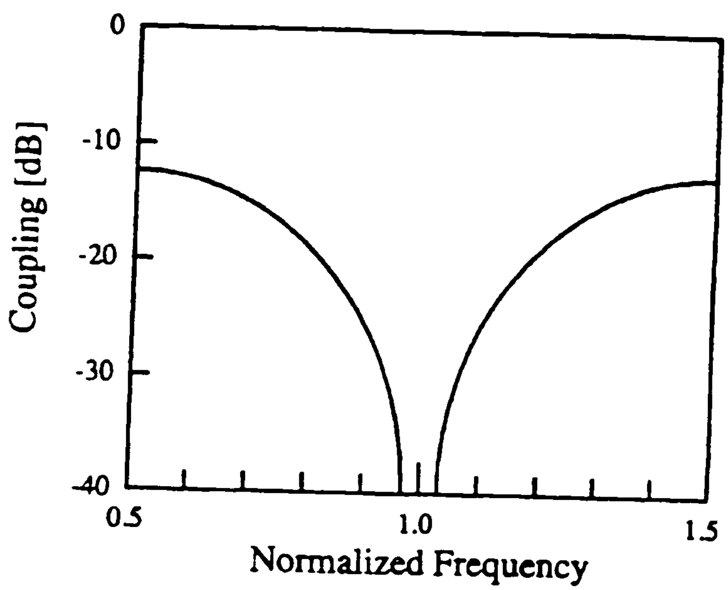
0
-10
-20
-30
-40
Coupling [dB]
0.5
1.0
1.5
Normalized Frequency

Fig.3

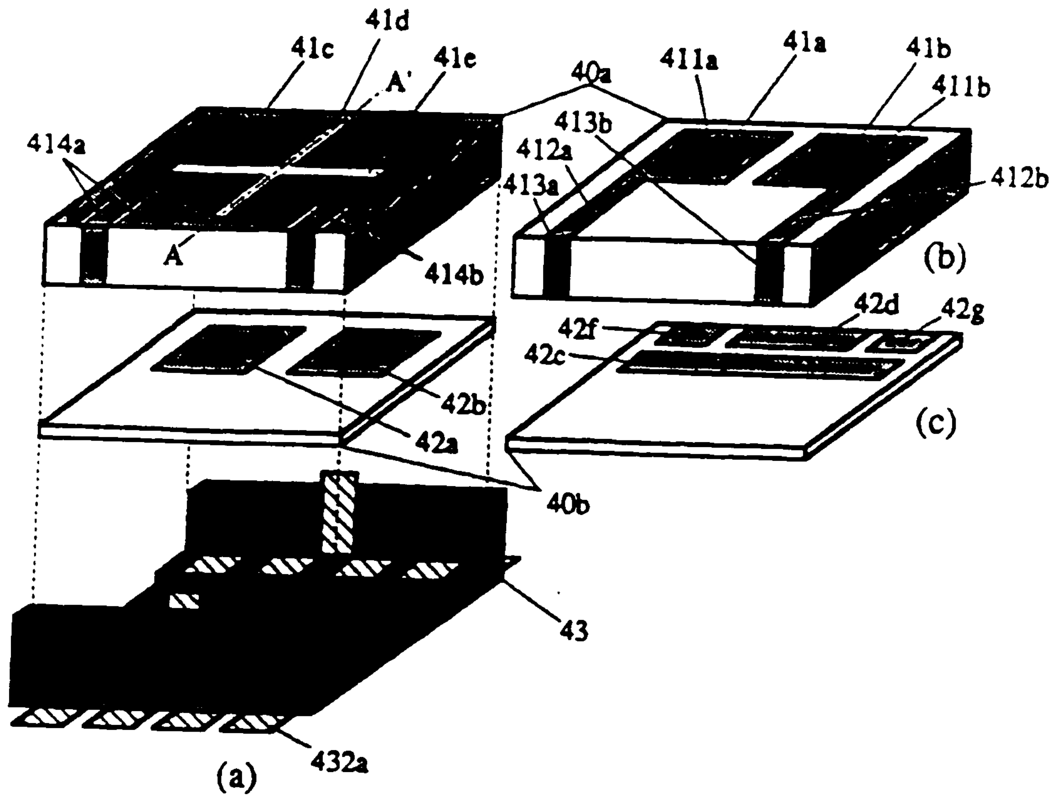
41c
41d
A'
41e
40a
411a
41a
41b
411b
414a
413b
412a
413a
412b
A
414b
(b)
42d
42g
42f
42c
42b
42a
(c)
40b
43
432a
(a)

Fig.4

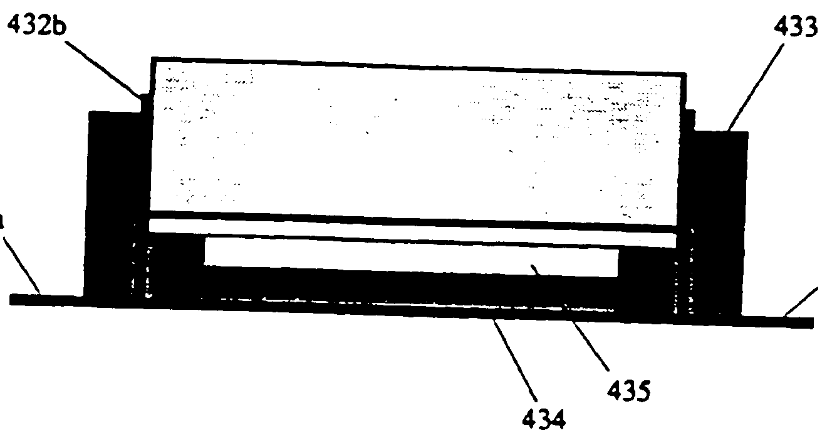
432b
433
432a
431
435
434

Fig.5

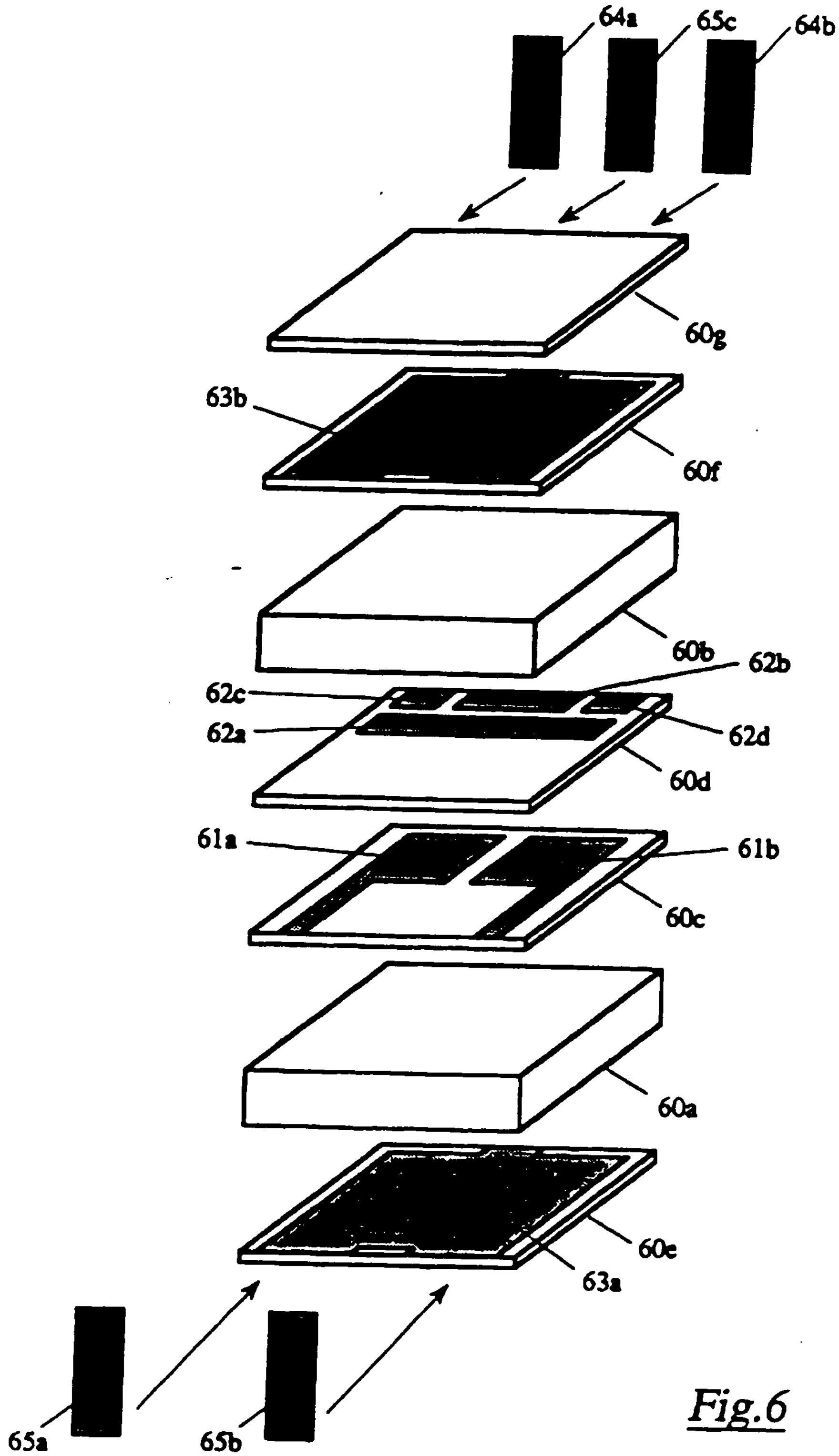
64a
65c
64b
60g
63b
60f
60b
62b
62c
62a
62d
60d
61a
61b
60c
60a
60e
63a
65a
65b

Fig.6